
THEMATIC MAPPER CRITICAL ELEMENTS BREADBOARD PROGRAM

NASA CONTRACT NAS5 - 20589

HUGHES AIRCRAFT COMPANY
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(NASA-CR-153989) THEMATIC MAPPER CRITICAL
ELEMENTS BREADBOARD PROGRAM Quarterly
Report, 1 October - 31 Dec. 1974 (Hughes
Aircraft Co.) 9 p

N77-81919

Unclas

00/43 40321

January 1975

Second Quarterly Report

October 1 - December 31, 1974

Prepared For
GODDARD SPACE FLIGHT CENTER
Greenbelt, Maryland 20771

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No. Second Quarterly	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle Thematic Mapper Critical Elements Breadboard Program		5. Report Date January 1975	
		6. Performing Organization Code	
7. Author(s) E. D. Harney		8. Performing Organization Report No.	
9. Performing Organization Name and Address Hughes Aircraft Company Space and Communications Group P. O. Box 92919 Los Angeles, California 90009		10. Work Unit No.	
		11. Contract or Grant No.	
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Goddard Space Flight Center Greenbelt, Maryland 20771		13. Type of Report and Period Covered Quarterly Report 1 October - 31 Dec. '74	
		14. Sponsoring Agency Code	
15. Supplementary Notes			
<p>16. Abstract</p> <p>The progress of the second three months of a twelve month breadboard development is presented. A detailed description of progress through December 6, 1974 was included in the PDR Information Material delivered on December 17, 1974 and is only summarized herein.</p> <p>All parts drawings are complete and fabrication is 80% complete. The sample and dummy mirrors are being polished for delivery by mid-January 1975.</p> <p>Tests to evaluate measurement accuracy in the ultimate test setup have begun. Initial indications are that cross axis error measurement accuracy will be better than 1 microradian.</p>			
17. Key Words (Selected by Author(s)) Mechanical scan mechanism Beryllium eggcrate mirror Voice coil torquer		18. Distribution Statement	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 8	22. Price*

1. INTRODUCTION

This report covers the second three months of the Thematic Mapper Critical Elements Breadboard Program progress extending from October 1, 1974 through December 31, 1974. The report is submitted in accordance with Article XVII of NASA Contract NAS 5-20589 and GSFC Specification S-250-P-1C for Type II Quarterly Reports.

2. SCOPE AND PURPOSE

The objective of the Thematic Mapper Critical Elements Breadboard Program is to produce a breadboard scan mirror assembly (SMA) for the Thematic Mapper and to demonstrate through tests that it will meet the specified performance. Specifically, the SMA will incorporate a 16" x 19" ultra lightweight beryllium mirror which must precisely scan bidirectionally without introducing significant optical and mechanical degradation to the overall Thematic Mapper instrument or other optical sensors aboard an Earth Observatory Satellite.

The work entails design and fabrication of a flight-type scan mirror and attachments with laboratory quality supporting structures and electronics. This hardware will then be assembled and mounted in a precision test facility and tested to demonstrate its scan precision and optical fidelity. The program duration is twelve and one-half months from go-ahead to submission of the Final Report draft.

3. SMA OPERATING CONCEPT

It was agreed during the first quarter to replace the MSS-type torquers with a voice coil approach, but to continue using the MSS drive and control logic until an acceptable torque-while-turnaround logic is demonstrated. The mirror motion on the retrace scan will therefore resemble the non-linear but highly repeatable MSS velocity profile. The provision for converting to a linear retrace motion will be included with the faster response of the voice coil torquers. Work accomplished on company funds during late 1974 confirmed that the necessary lower loss type spring-damper mechanism for a torque while turnaround implementation is now ready for use in the Thematic Mapper. Work is continuing to prove out the control logic for demonstrating linear motion for both directions of scan.

4. STATUS SCHEDULE

Figures 1 and 2 portray the overall schedule and milestone interdependencies as well as completed effort through the end of this reporting period. It should be noted that the scheduled informal Preliminary Design Review was held at Hughes on December 6, 1974. This was attended by Mr. L. Eugene Austin, a local NASA representative, but NASA technical personnel from GSFC were unable to attend. Therefore, a 30-page PDR report ⁽¹⁾ was prepared and forwarded with addended back-up material to Mr. Weinstein, the contract Technical Officer. Hughes personnel are also prepared to address followup questions from GSFC in person upon request. That report described all progress through December 6 and therefore only summary progress inputs are included below.

Notable changes which have occurred in the schedules shown in Figure 1 and 2, none of which have created a delay in the scheduled completion of the project, are as follows:

- a. The sample mirror fabrication completion was delayed causing a delay in the expected completion of test on the sample mirror. This mirror is at the polisher and should be delivered by January 16, 1975. This will cause no delay in the expected receipt date of the flight-type mirror.
- b. The analytic analysis of cross-axis measurement errors was eliminated (as mentioned in the PDR) and replaced by a test. It is expected that the suitability of the intended test set-up will be verified by 1/10/75. Should modifications be required, they are scheduled to be designed by 1/31/75 and built by 2/15/75. Should no cross-axis measurement changes be required, we still schedule test set-up and calibration by 1/24/75.
- c. The completion schedule for fabrication of parts will be met with the exception of one part, the optical switch reticle. Assembly procedures were rescheduled to avoid a slip in the final assembly date. The vendor's delivery date is January 17. Parts were approximately 80% complete by the close of this reporting period and assembly was under way.
- d. The dummy mirror will be returned from the polisher to HAC by 1/15/75 which is about a one-week slip. This should not change the SMA assembly completion date.

5. TECHNICAL STATUS

The written PDR information⁽¹⁾ presented in detail presents the current technical status of the program. In the short time since its writing, few changes have occurred.

The manufacture of the three mirrors (flight-type, sample, and a dummy mirror) has exhibited a few minor difficulties. As mentioned in the PDR, procedural problems arose in the brazing process during fabrication of the sample mirror. These problems were solved, the sample mirror was fabricated, and radiographic inspection validated the success of the revised procedure which was used. Solving these difficulties on the sample mirror has helped the vendor in the manufacture of the flight-type mirror. The first braze attempt on the flight-type mirror, however, was unsuccessful as a result of faulty temperature control. The configuration of the mirror on the braze oven has been modified and no further problems are foreseen in the manufacture of the flight mirror. A fabrication error in the dummy mirror (used to provide test opportunity prior to receipt of the flight mirror) required rework and delivery slip of about a week.

Initial measurements have been made to determine the uncertainty associated with the cross-axis measurement equipment. Based upon initial tests, the cross-axis uncertainty in a measurement is less than one microradian. This assumes the use of a porro mirror which introduces 5 bounces of the laser beam between the porro and scan mirrors and a 100 inch focal length lens in the optical path between the scan mirror and the beam position detector. Although this value of measurement error is acceptable, the actual uncertainty may be less if the observed noise can be further reduced. The observed noise contained low frequency components which were found to be caused by an anomaly in the laser source. These components may be so low as to be outside of the measurement bandpass, particularly for scan to scan measurements. Alternative lasers will be tried to relieve this error source. The high frequency component was at 120 Hz and can probably be traced to the lab power and removed. The remaining noise appeared to be broad based at very high frequency.

The test specification was written and included in the written PDR material.

It is assumed that this specification meets the approval of NASA and it is being incorporated into the overall Development Specification for the TM/SMA (DS31649-001, Rev. A). Work has started on preparation of the Test Plan and Test Procedures documentation.

6. NEW TECHNOLOGY

The effort on this contract thus far has been limited to design, fabrication, assembly and test of a Scan Mirror Assembly (SMA) for a Thematic Mapper. This assembly closely resembles the SMA for the operational Multispectral Scanner purposely to reduce risks. This approach tends to preclude the incorporation of "new technology" per se. A close review of the design and operating concept of this new SMA has been made and, on a part by part basis, it was confirmed that no new technology has been incorporated.

7. PROGRAM FOR THE NEXT QUARTER

The manufacturing and assembly of all SMA and test fixture parts will be completed approximately midway through the quarter.

The test setup will be completed, calibrated and integrated with the SMA. The SMA will be optimized as to mechanical properties such as flex pivot balance, bumper spring force and damper size using the dummy mirror. Following this, complete system tests will be conducted with this mirror to check out all equipment prior to installation of the flight type mirror.

The polished sample mirror (6" x 9") will be received, undergo static flatness testing and evaluated for other mechanical and optical properties.

Near the end of the quarter the polished and coated flight type mirror will be received and will undergo static and dynamic flatness tests.

Test plans and procedures will be completed and forwarded to GSFC^{NSFC} for review prior to the Major Design Review scheduled at the end of the quarter and prior to initiation of performance tests with the flight type mirror.

8. CONCLUSIONS

The most significant problems encountered during this quarter were in the manufacturing of the eggcrate mirrors. In each case satisfactory solutions were found and the necessary rescheduling was accomplished without threatening the

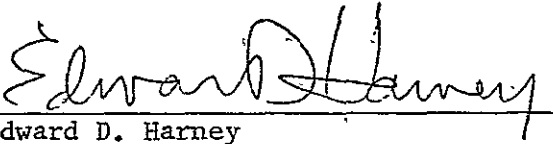
overall program schedule. These anomalous events were not unexpected and served as valuable learning steps toward mastery of the production of the desired flight mirror.

The uncertainties in cross-axis measurement capabilities appear to be resolved without having to resort to unreasonable measures.

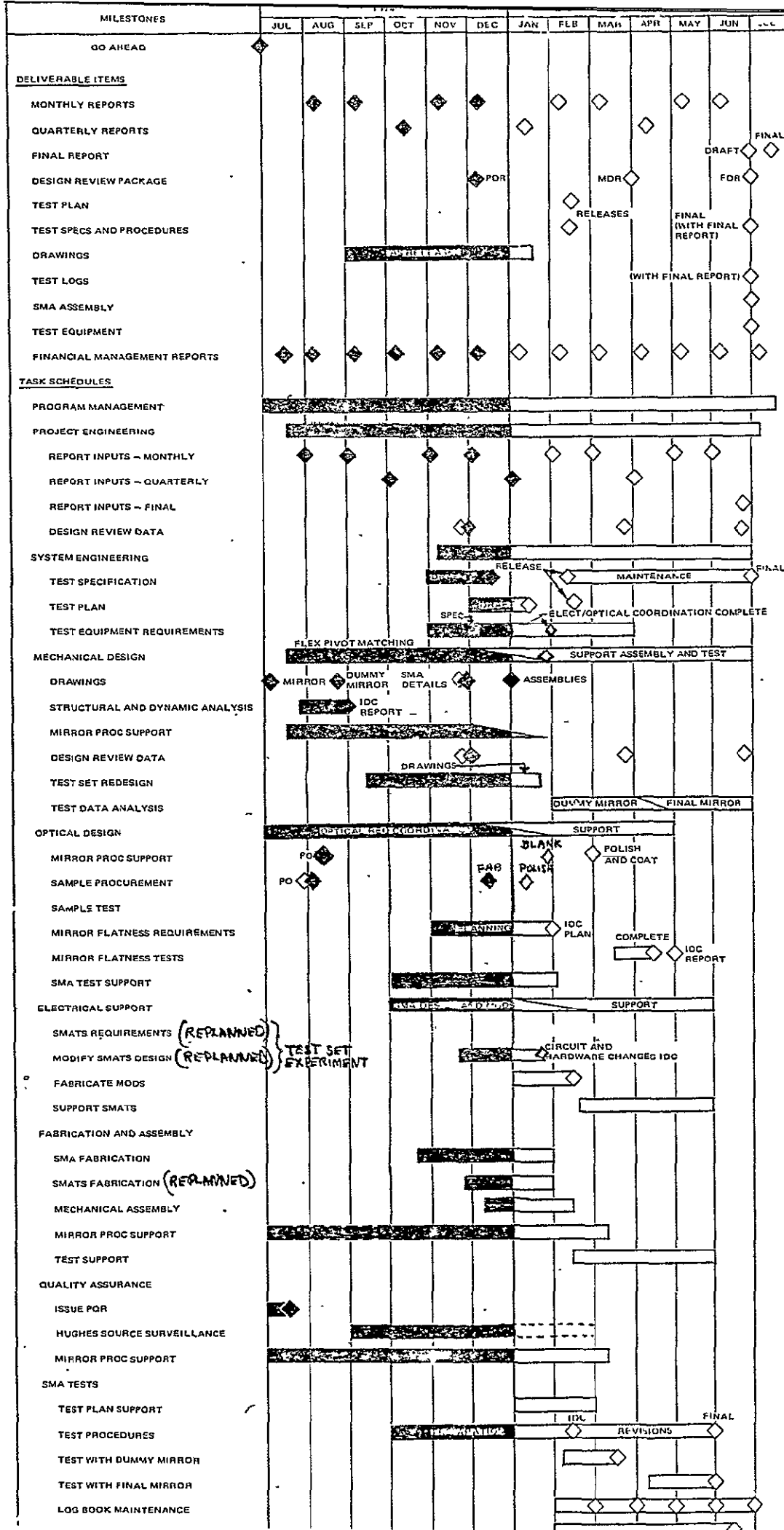
The success to date of company funded work to achieve a fully linear bi-directional scan capability for Thematic Mapper is such as to assure that an acceptable solution will be in hand during the next quarter.

9. RECOMMENDATIONS

None.


Edward D. Harney

Reference (1): Hughes letter 74(44)19593/D2241 "SMA PDR Information Material" with addended data package to GSFC dated December 10, 1974.



THEMATIC MAPPER BREADBOARD MILESTONE SCHEDULE

FIGURE 1.

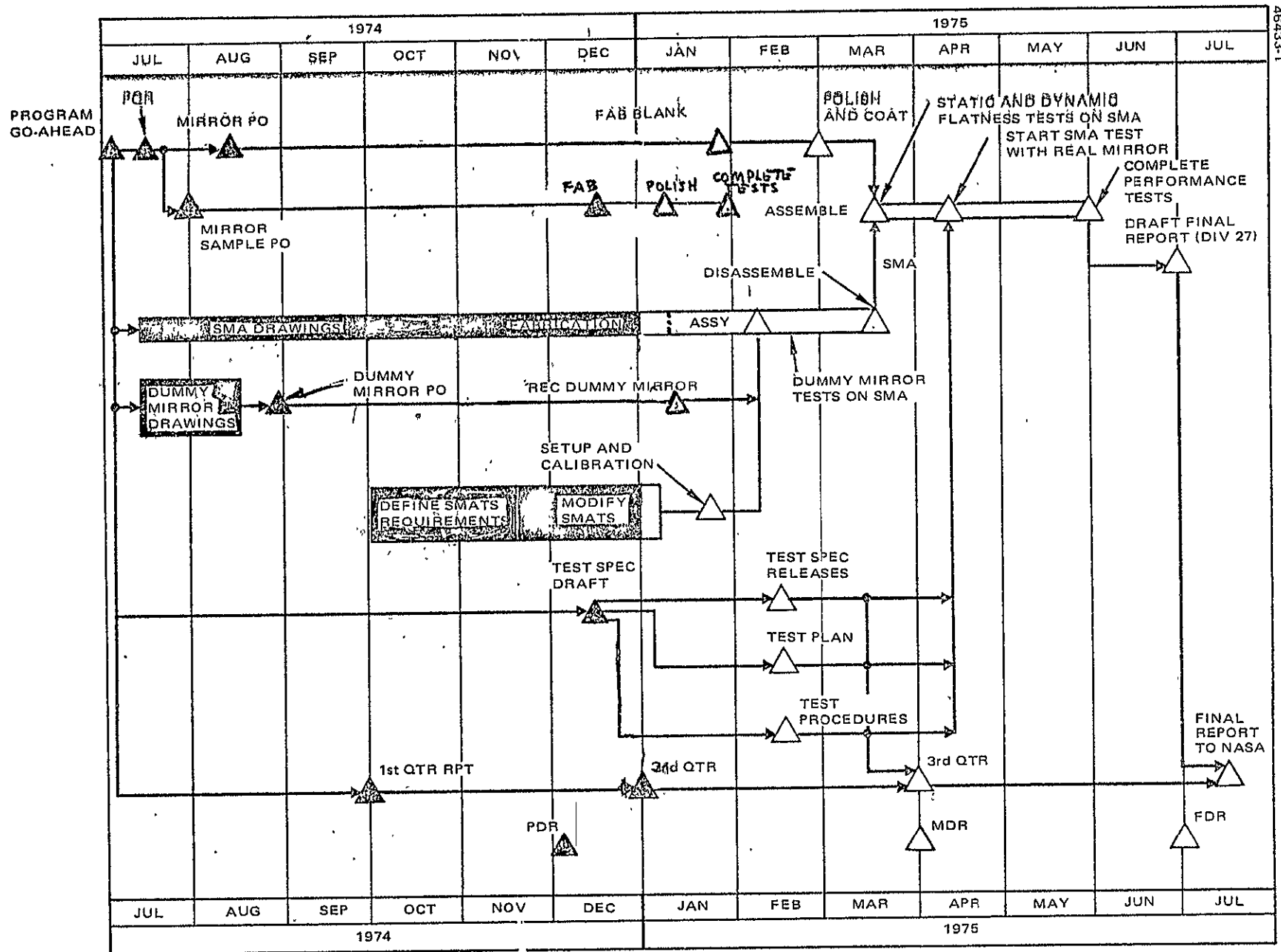


FIGURE 2. THEMATIC MAPPER SCAN MIRROR ASSEMBLY - PROGRAM MILESTONE INTERDEPENDENCIES
TIME PHASED PER PROPOSED SCHEDULE